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M.R.P. 868

S.C.II/172

9th June, 1954

AIR MINISTRY

METEOROLOGICAL RESEARCH COMMITTEE

Note on exceptionally severe clear-air turbulence and other phenomena on 14th April, 1954

by

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1. Introduction

Very severe turbulence experienced in clear air at heights between 28,000 and 41,000 ft. have previously been described and the meteorological situations on these occasions discussed (1, 2).

An exceptionally severe patch of turbulence was recently encountered without warning by a Canberra jet bomber flying at 40,000 ft. There were also reports of very strong "Standing Waves" in the same airstream but at different times and several different locations.

2. Description of the turbulence

At about 2130 G.M.T. on April 14th, 1954 a Canberra aircraft was flying at 40,000 ft. on a heading of 084 degrees (true) near Edinburgh. After flying in smooth air conditions at an indicated air speed of 210 kt. (.7 Mach Number) the aircraft suddenly experienced severe turbulence. The pilot began to turn to the right to avoid the region of turbulence but during the turn a severe gust lifted the port wing and rolled the aircraft on to its back. Full aileron control proved ineffective in preventing the roll and while upside down the aircraft gained 500 ft. in altitude. Control was eventually regained and the aileron became effective again. The pilot then descended quickly and found that turbulence ceased below 38,000 ft. The aircraft returned to its base and landed safely. No damage was found to have been suffered by the Canberra.

The only cloud in the vicinity of the incident was about 3/8 cumulus below 20,000 ft.

3. Meteorological situation

Fig. 1 shows the surface chart for 0001 hours and Fig. 2 the 300 mb. chart for 0200 G.M.T. 15th April.

The depression over Southern Scandinavia was moving southeastwards. The associated cold front was moving slowly southwards over Northern England and was being followed by a secondary cold front which was over Northern Scotland.

At high levels the whole of the British Isles and the North Sea were under the influence of a strong northwesterly air current. There are indications of a well marked jet stream with its axis extending from Iceland to the Shetlands to North West Germany. Fig. 3 shows a cross-section from Valentia to Lerwick at 0200 G.M.T. 15th April which is the time nearest to that of the incident under

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discussion when temperature and wind soundings were made simultaneously. Only upper winds are observed at 2000 hours and those for stations in Scotland, Northern Ireland and Northern England on the evening of 14th April are given in Table I.

Table I

Winds at 2000 hours 14th April, 1954

	Lerwick	Leuchars	Stornoway	Liverpool	Aldergrove
24,000 ft.	315/132 kt.	310/67 kt.	313/75 kt.	322/59 kt.	306/58 kt.
27,000 "	316/118	302/77	302/82	316/65	308/55
30,000 "	316/118	300/80	295/89	313/60	298/49
35,000 "	316/135	303/83	296/88	309/53	289/46
40,000 "	318/138	309/68	312/40	309/50	287/42
45,000 "	318/125[x] (42,000 ft.)	314/43	293/22	351/32	312/47

[x] (The wind at 45,000 feet is given in the Daily Aerological Record as 318/144 kt. but this was computed from the last minute of the observation at the extreme range of the radar and the Senior Meteorological Officer, Lerwick advises that this value is probably in error).

It will be seen that when the incident occurred the aircraft was flying in the upper troposphere, in a region of pronounced vertical and horizontal wind shear, on the warm side of the jet stream and above the level of the axis of the jet.

4. Reports of "Standing Waves"

At the debriefing of the pilot involved in the above incident he stated that the only unusual conditions he noticed before the onset of the very severe turbulence were found over the Midlands previously that evening. At a height of 40,000 ft. he noticed up and down currents, and variations in the indicated air speed which he thought were caused by "standing waves".

Another interesting report showing the existence of strong vertical currents was received from the pilot of a jet fighter aircraft who was doing a flight to check his R/T set. While trying to fly straight and level at 35,000 ft. over Norwich at an indicated air speed of 200 kt. at about 1100 hours 14th April he noticed that the vertical Airspeed Indicator and the Altimeter were registering a rate of climb of 3,000 ft. per minute. He then tried to descend and in his report states -

"I was now at 37,000 ft. I noticed that I was still in cirrus cloud. My rate of climb still showed 3,000 ft. per minute and the Altimeter reading rose quickly to just under 40,000 ft. I was still in cirrus cloud. I then opened the throttles and dived out to the south to carry out further R/T checks at lower altitudes.

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My aircraft was heavily laden and should, once I had levelled off, have been unable to climb at anything more than 1,000 ft. per minute at the beginning, and when the nose was down should have lost height at least at 2,000 ft. per minute, probably more.

There was no vestige of turbulence during the climbing incident which took place 10 miles south of Norwich".

The existence of standing waves in the air stream at lower levels has subsequently been confirmed by the large number of reports received at Northolt from civil aircraft. During the period 13th - 15th April about 30 reports of standing waves were received, the heights at which they were reported varied from 4,500 ft. to 18,000 ft. and the rates of lift and sink ranged up to 2,000 ft. per minute. It has been stated that the number of reports in this period was exceptional; the usual rate of receiving such reports is about 2 or 3 per week.

5. Discussion

There were other reports of high level turbulence over the British Isles on the 14th April. The existence also of standing waves at various levels at more or less the same time poses a problem as to whether the turbulence is in some way associated with standing waves which are generated when wind blows over a mountain range. Hislop tentatively suggested in his report on the British European Airways special investigational flights (3) that under certain conditions the waves might break - (like the waves of the sea) - and thus degenerate into turbulent motion. He quotes an occasion when a B.E.A. Mosquito experienced smooth lift of about 1,500 ft. to 2,000 ft. per minute between 35,000 and 37,000 ft. which finally petered out into rather sluggish turbulence. It has also been suggested by Radok (4) that topography can be responsible for localising and rendering severe turbulence within a favourable jet stream region. But on the other hand, Press, Schindler and Thompson (5) reported after a recent investigation that clear air turbulence had been reported in all parts of the United States and there were no indications of geographical variations, which would be the case if there were an association between the two phenomena.

6. Conclusions

The incident of the Canberra which encountered, in clear air, a gust of sufficient violence to turn it upside down while in normal flight focuses attention on the extreme severity of turbulence that may be encountered at high level. So far as is known no such incident has previously been reported. It occurred on the warm side of the jet stream, about 250 miles from the axis and above the level of the axis. The depth of the turbulent layer was about 2,000 ft.

The simultaneous occurrence of high level turbulence and standing waves raises a question as to whether there is any connection between them, but no conclusive evidence one way or the other has been found so far. Further work on this aspect of turbulence might be desirable.

References

1. Hislop, G.S.; Clear air turbulence incident encountered by D-H "Comet" aircraft, 14th November, 1949. British European Airways R.S.D. Note No. 41, London, 1949.

2. Bannon, J.K.; Severe turbulence encountered by aircraft near jet streams. Met. Mag. London, 80, 1951, p. 262.

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3. Hislop, G.S. Clear Air Turbulence over Europe. J.R. Aero Soc. 55, 1951, p. 199.

4. Radok, U; Severe turbulence at high levels over New South Wales. Met. Mag. London,83, 1954, p. 48.

5. Press, Schindler and Thompson; Summary of pilots' reports of clear air turbulence at altitudes above 10,000 ft. N.A.C.A. Report RML52 L30.a.

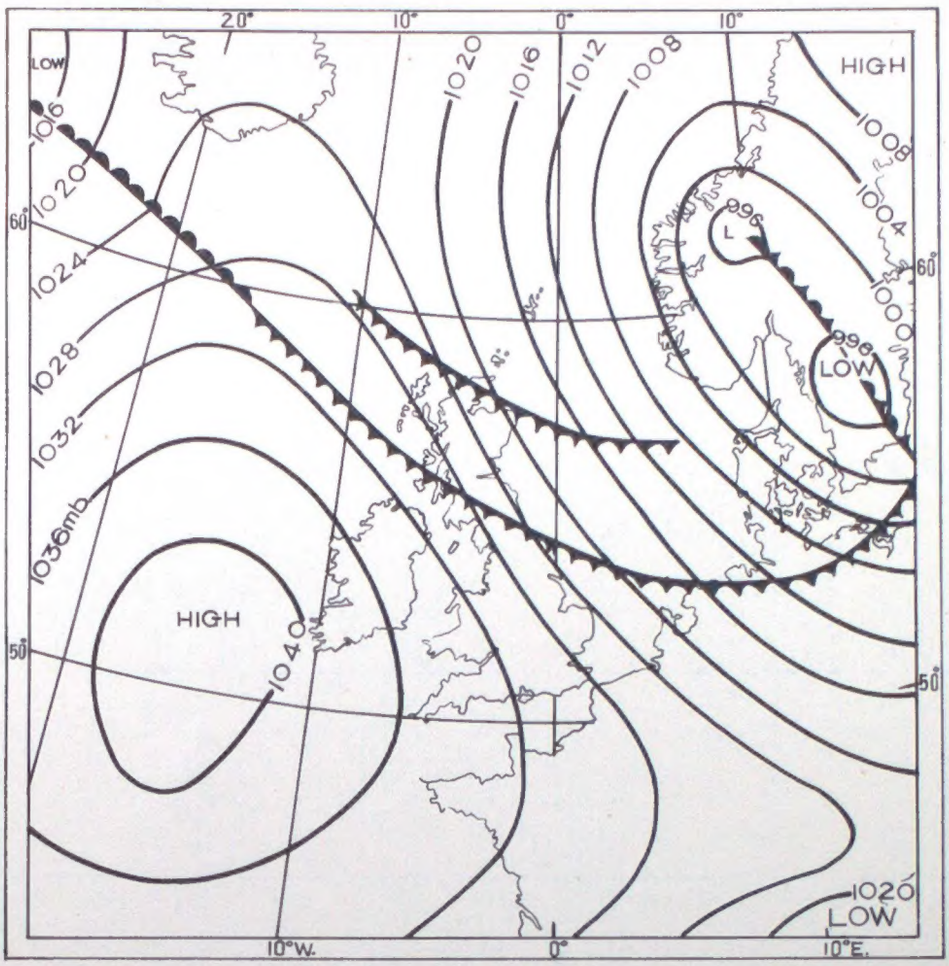


Fig.1 Surface synoptic chart for 0001 G.M.T. 15th April 1954

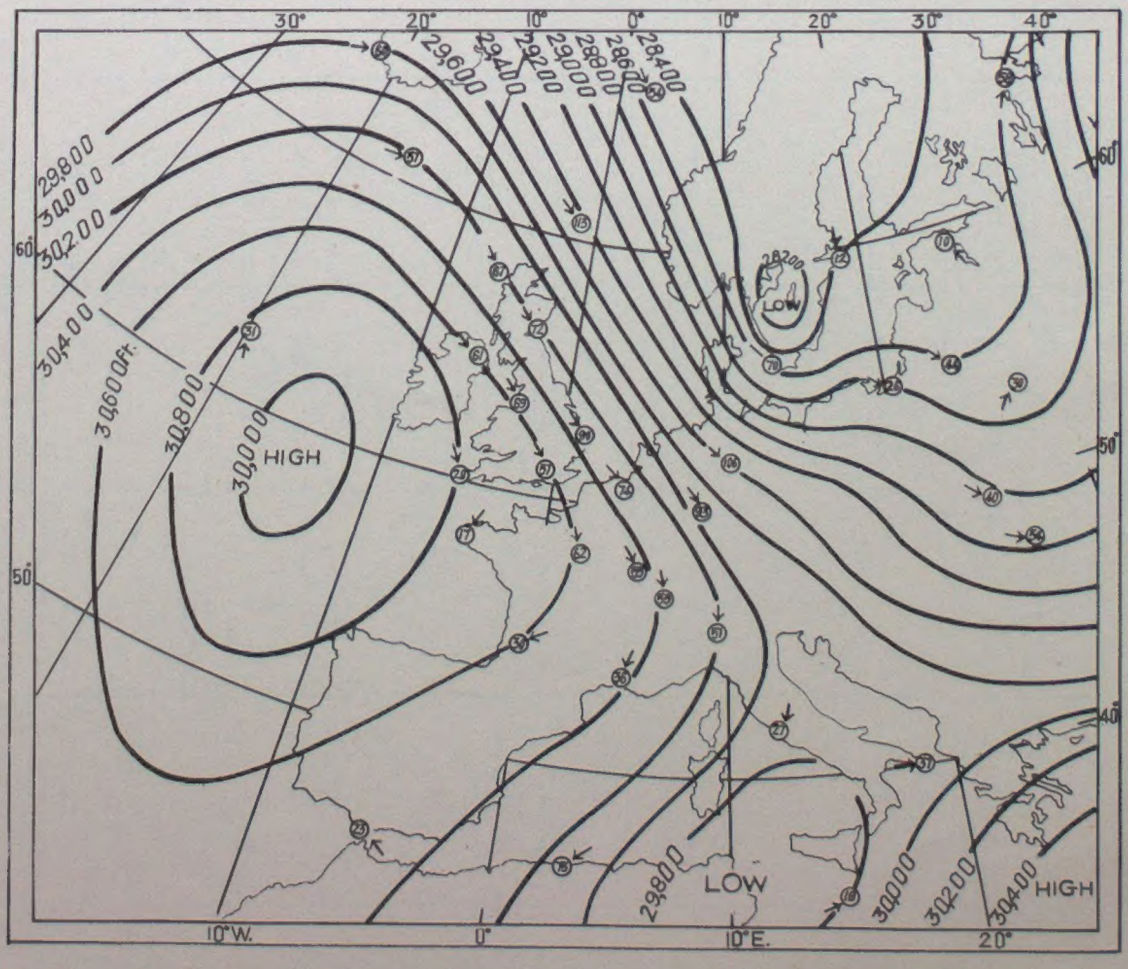
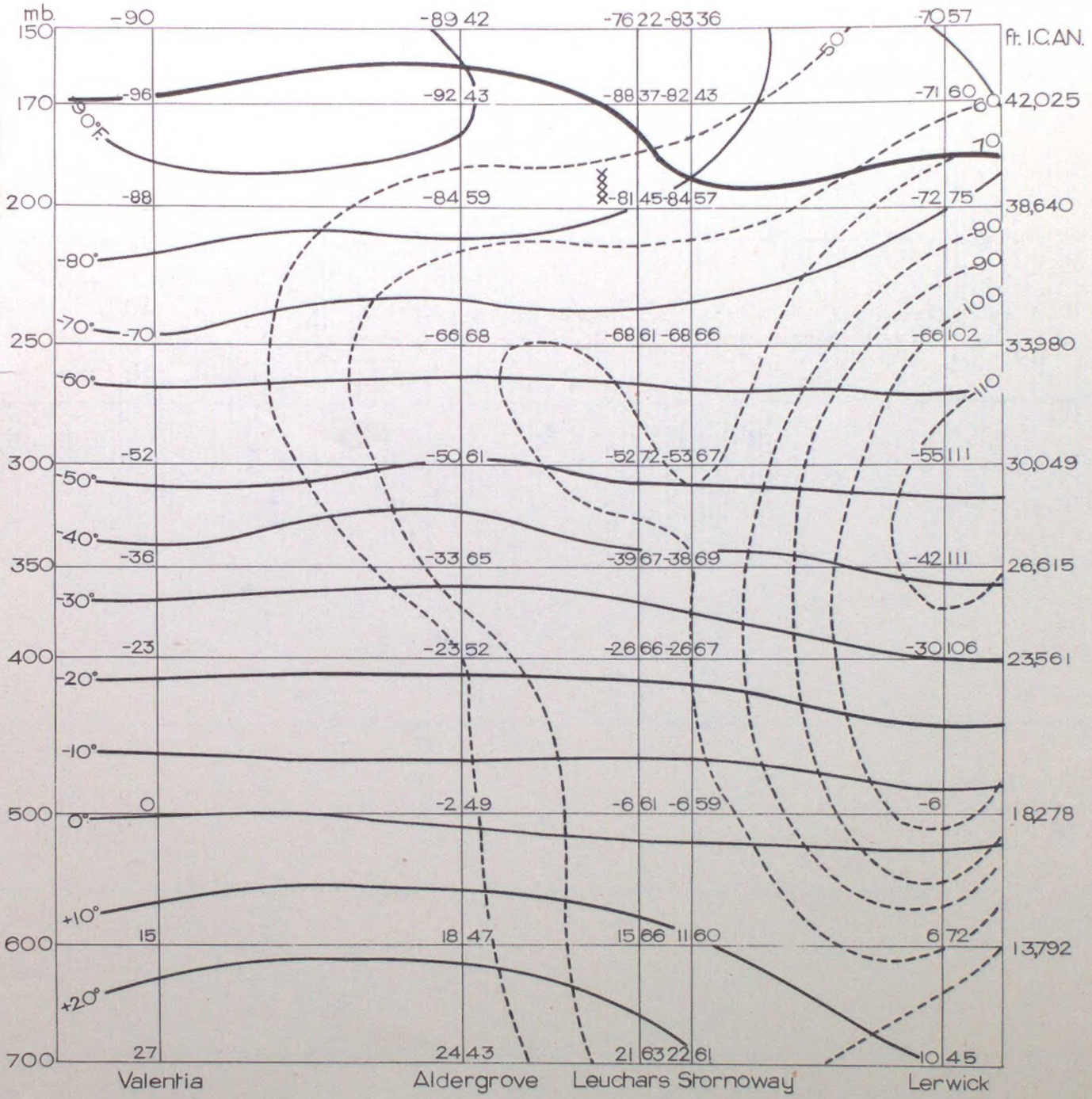


Fig.2 Contours of the 300mb. pressure level at about 0200 G.M.T. 15th April 1954



---Isopleths of wind velocity component from 310°(kt)
——Isotherms (°F.)
——Tropopause surface
Exceptionally severe turbulence experienced at 2130 G.M.T. 14th April 1954

For each ascent the temperature °F. is given on the left, and component of the wind velocity from the direction 310° on the right, at the specified levels.

Fig. 3 Cross section Valentia to Lerwick 0200 G.M.T. 15th April 1954